

1 **What is claimed is:**

2 1. A method for forming a bottle-shaped trench,
3 comprising:

4 providing a semiconductor substrate with a trench
5 having a pad stack layer thereon;
6 filling a mask layer into the lower portion of the
7 trench;
8 using plasma nitridation to form a sidewall nitride
9 layer on the trench sidewall;
10 removing the mask layer; and
11 etching the lower portion of the trench to form a
12 bottle-shaped trench.

1 2. The method as claimed in claim 1, wherein the
2 pad stack layer comprises an oxide layer and a nitride
3 layer.

1 3. The method as claimed in claim 1, wherein the
2 mask layer is a photoresist material.

1 4. The method as claimed in claim 1, wherein the
2 plasma nitridation temperature is 25~100°C.

1 5. The method as claimed in claim 1, wherein the
2 lower portion of the trench is etched by wet etching.

1 6. The method as claimed in claim 5, wherein the
2 wet etching solution is ammonia (NH₄OH + H₂O).

1 7. The method as claimed in claim 1, wherein the
2 plasma nitridation pressure is 30~50Pa.

1 8. The method as claimed in claim 1, wherein the
2 plasma is RF plasma.

1 9. The method as claimed in claim 8, wherein the
2 RF power is 500~1000W.

1 10. A method for forming a bottle-shaped trench,
2 comprising:

3 providing a semiconductor substrate with a trench
4 having a pad stack layer thereon;

5 filling a photoresist layer into the lower portion
6 of the trench;

7 using 25~100°C plasma nitridation to form a sidewall
8 nitride layer on the pad stack layer and the
9 trench sidewall;

10 removing the photoresist layer; and

11 etching the lower portion of the trench to form a
12 bottle-shaped trench.

1 11. The method as claimed in claim 10, wherein the
2 lower portion of the trench etching is wet etching.

1 12. The method as claimed in claim 11, wherein the
2 wet etching solution is ammonia (NH₄OH + H₂O).

1 13. The method as claimed in claim 10, wherein the
2 plasma nitridation press is 30~50Pa.

1 14. The method as claimed in claim 10, wherein the
2 plasma is RF plasma.

15. The method as claimed in claim 14, wherein
the RF power is 500~1000W.

16. A method for forming a bottle-shaped trench, comprising:

providing a semiconductor substrate with a trench having a pad oxide layer and a nitride layer thereon;

filling a mask layer into the lower portion of the trench;

etching a portion of the pad oxide layer near the trench to reveal a corner of the substrate:

10 using plasma nitridation to form a sidewall nitride
11 layer on the trench sidewall and to fill the
12 pad oxide recess;

13 removing the mask layer; and

14 etching the lower portion of the trench to form a
15 bottle-shaped trench.

17. The method as claimed in claim 16, wherein the mask layer is photoresist.

18. The method as claimed in claim 16, wherein the plasma nitridation temperature is 25~100°C.

19. The method as claimed in claim 16, wherein the lower portion of the trench is etched by wet etching.

20. The method as claimed in claim 19, wherein the wet etching solution is ammonia ($\text{NH}_4\text{OH} + \text{H}_2\text{O}$).

21. The method as claimed in claim 16, wherein the plasma nitridation press is 30~50Pa.

1 22. The method as claimed in claim 16, wherein the
2 plasma is RF plasma.

1 23. The method as claimed in claim 22, wherein the
2 RF power is 500~1000W.

1 24. A method for forming a bottle-shaped trench,
2 comprising:

3 providing a semiconductor substrate with a trench
4 having a pad oxide layer and a nitride layer
5 thereon;

6 filling a photoresist layer into the lower portion
7 of the trench;

8 etching a portion of the pad oxide layer near the
9 trench to reveal a corner of the substrate;

10 using the 25~100°C plasma nitridation to form a
11 sidewall nitride layer on the trench sidewall
12 and to fill the pad oxide recess;

13 removing the photoresist layer; and

14 etching the lower portion of the trench to form a
15 bottle-shaped trench.

1 25. The method as claimed in claim 24, wherein the
2 lower portion of the trench is etched by wet etching.

1 26. The method as claimed in claim 25, wherein the
2 wet etching solution is ammonia (NH₄OH + H₂O).

1 27. The method as claimed in claim 24, wherein the
2 plasma nitridation pressure is 30~50Pa.

1 28. The method as claimed in claim 24, wherein the
2 plasma is RF plasma.

1 29. The method as claimed in claim 28, wherein the
2 RF power is 500~1000W.